Distributed Air-Ground Traffic Management Research

Human Factors and Operations
Project
NASA Ames Research Center

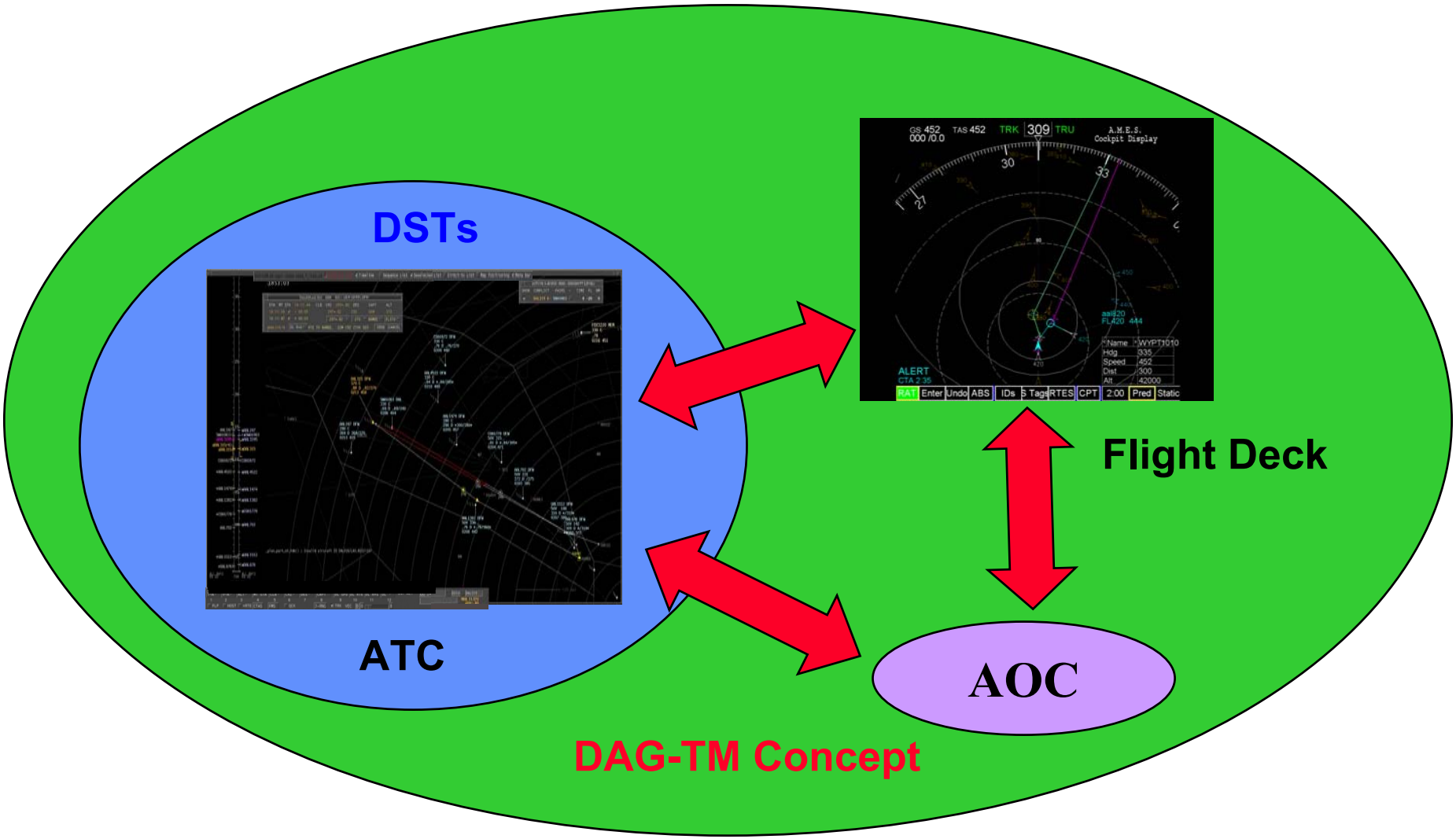
Advanced Air Transportation Technologies Project

- **Goal**
  - **In alliance with the FAA, enable the next generation of increases in efficiency, flexibility, capacity, and safety of aircraft operations within the US and global airspace system.**
- **Focus**
  - **Develop human-centered automation to assist air traffic management in short and intermediate term decision making between pilots, controllers, and dispatchers.**

Focus Areas

- Develop en route and terminal decision support tools for FAA Free Flight Phases 1 and 2
  - Enhance capabilities of present air traffic system
  - Deliver CTAS decision support tools to the FAA
- Distributed Air-Ground Traffic Management (DAG-TM) Research
  - Free Flight concept exploration
  - Evaluate feasibility of making major changes to current system and procedures
  - Deliver tested concepts to the FAA

CTAS Tools and DAG-TM



DAG-TM Concept Elements

- Four concept elements (CEs) are being pursued:
  - CE-5: Free Maneuvering for User-preferred Separation Assurance and Local traffic flow management (TFM) Conformance
  - CE-6: Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance
  - CE-7: Collaboration for Mitigating Local TFM Constraints due to Weather, Special Use Airspace, and Complexity
  - CE-11: Self-spacing for Merging and In-trail Separation

Assumptions for DAG FY'01

- All aircraft are FMS, data link, and CDTI equipped.
- Aircraft are not RTA equipped at this point in development. However…
- ➔ *During the September 2001 simulation, meter fix RTA advisories will be uplinked to arriving aircraft, along with cruise speed advisories to assist them in meeting the recommended RTA.*
- All aircraft at or above FL290 are in Free Flight, all aircraft at or below FL280 are ATC-controlled.
- Aircraft must be cleared to enter Free Flight airspace (FL290 and above).
- Aircraft must be cleared to descend below FL290, and will be transitioned to positive control by ATC at that time.
- ATC may cancel Free Flight at any time.
- All arriving aircraft are flying the Bowie F2 Arrival.

Roles and Responsibilities

General Rules

- *Only one entity (flight crew or ATC) is responsible for separation at any time.*
- ATC has the sole authority to cancel self-separation
- Pilot can request the cancellation of free-flight

En Route Free Flight – Flight Crew Responsible

- Flight crew (upon acceptance) is responsible for separation assurance
- Flight crew can request ATC assistance for conflict resolution, flow control, and traffic management considerations
- NOTE: If request for assistance is not received in a timely manor the flight crew is responsible for any loss of separation, but controller should assist the flight crew as soon as possible.

Transition Phase – Flight Deck Responsible (FL290 and above)

- ATC will provide "RTA" (Required Time of Arrival) advisory for meter fix
- Flight crew is responsible for separation and meeting RTA clearance time

Transition Phase – ATC Responsible (below FL290)

- Controller is responsible for separation and meeting meter fix arrival time
- Flight crew can request flight plan change
- Controller should consider user preferences

TRACON in trail spacing - ATC responsible for separation

- Flight crew can be cleared to maintain in-trail spacing, +/- buffer 70 sec +/- 10 sec)
- Controller can revoke clearance at any time (redundant)

DAG Overview: September 2001 Simulation

ADVANCED AIR TRANSPORTATION TECHNOLOGIES

DAG-TM Research | **September 2001**

Pilots use CDTI trajectory tools to resolve traffic conflicts. All changes are broadcast.

Free Flight to Controlled Flight Transition

Pilots may begin descent in Free Flight, but must transition to positive control before descending **below FL290**.

High altitude (super sector) controllers uses CTAS tools (TMA, conflict probe) to monitor en route and arrival aircraft.

Pilots use FMS to fly precise VNAV descents from TOD to the TRACON boundary.

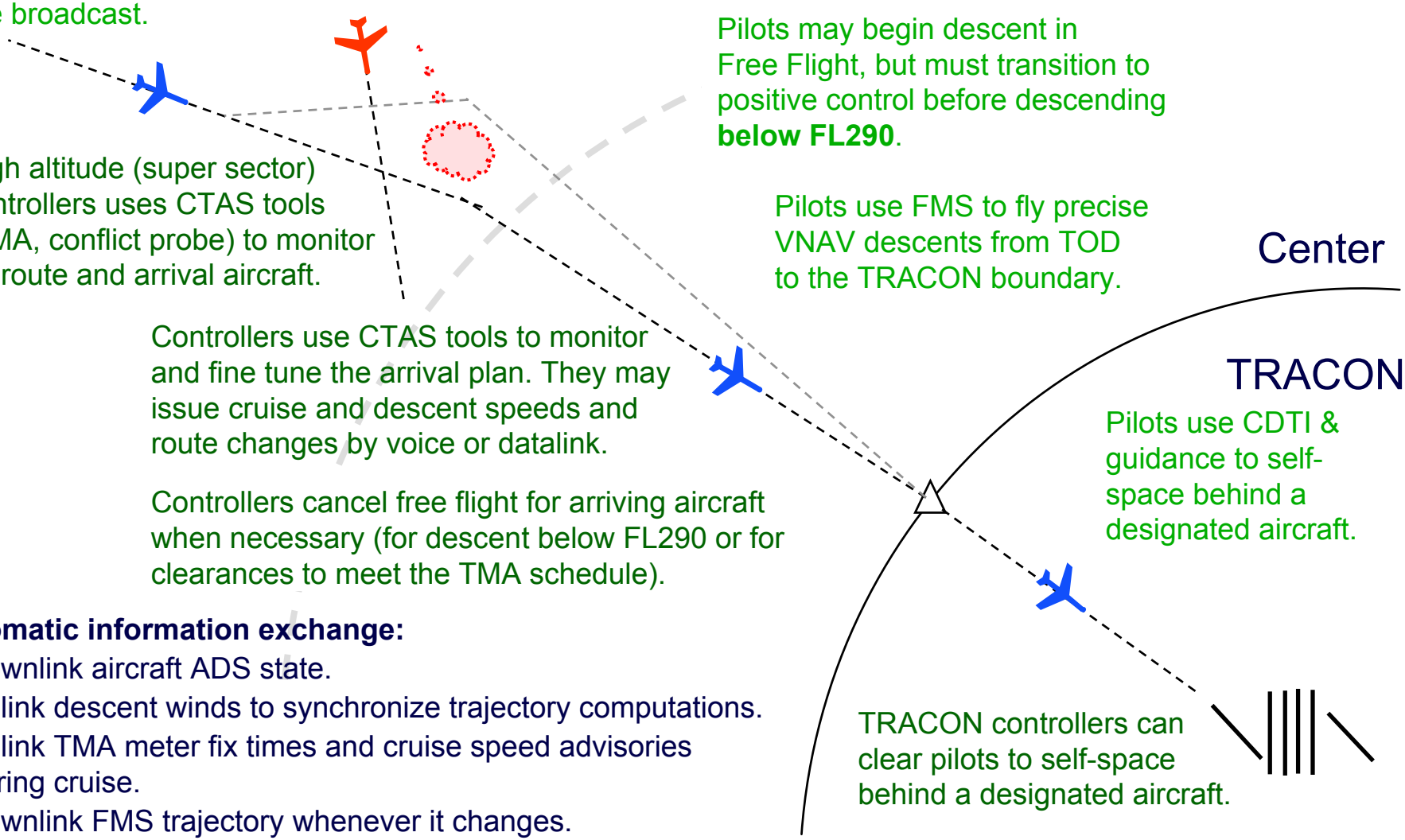
Center

Controllers use CTAS tools to monitor and fine tune the arrival plan. They may issue cruise and descent speeds and route changes by voice or datalink.

TRACON

Pilots use CDTI & guidance to self-space behind a designated aircraft.

Controllers cancel free flight for arriving aircraft when necessary (for descent below FL290 or for clearances to meet the TMA schedule).

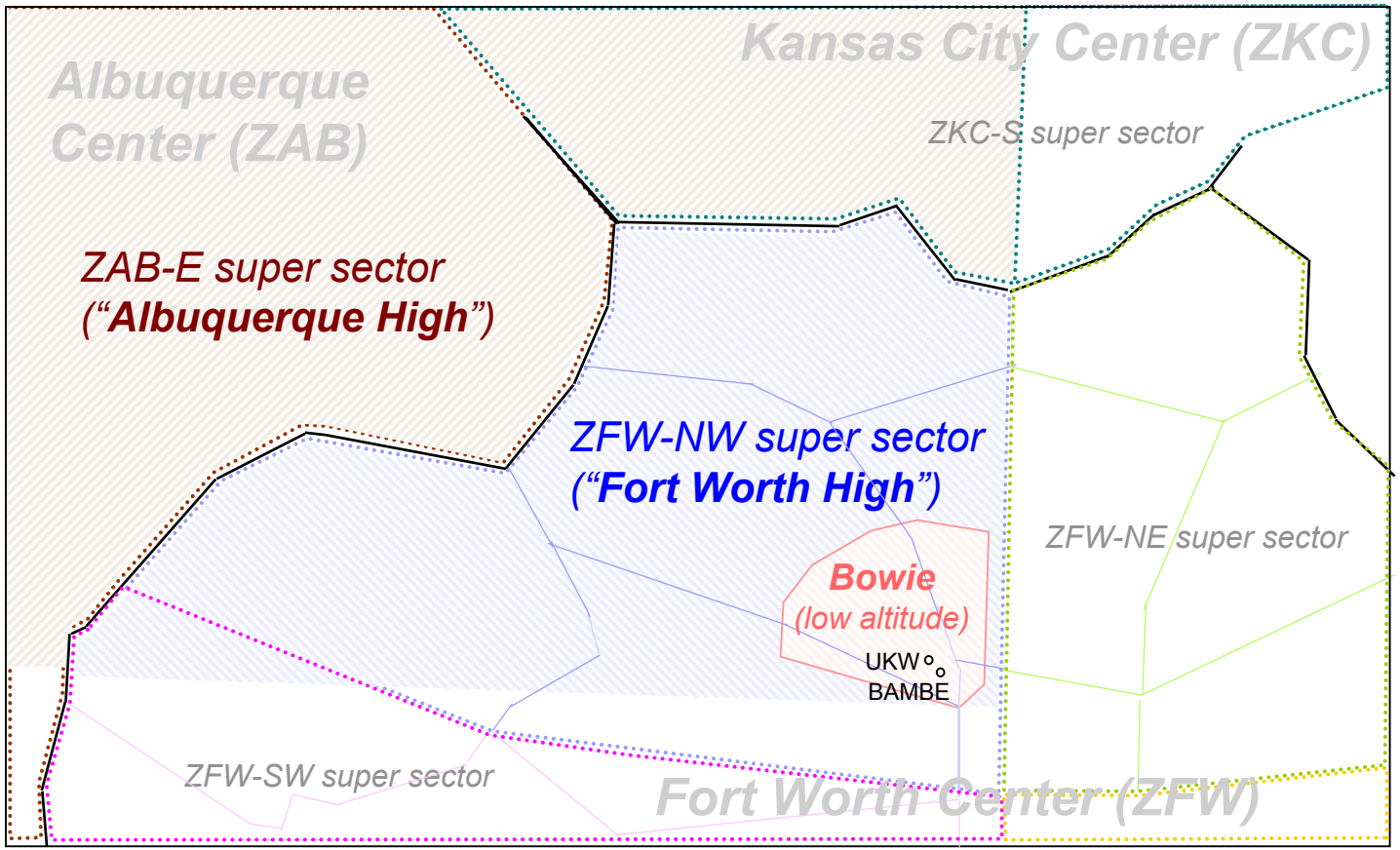


Automatic information exchange:

- Downlink aircraft ADS state.
- Uplink descent winds to synchronize trajectory computations.
- Uplink TMA meter fix times and cruise speed advisories during cruise.
- Downlink FMS trajectory whenever it changes.

TRACON controllers can clear pilots to self-space behind a designated aircraft.

Center Airspace for DAG-TM Simulations



CE-5:
Free Maneuvering for User-preferred Separation Assurance and Local TFM Conformance

- **Problem:**
  - **Potential traffic separation conflicts may cause controller-issued deviations that are conservative or not preferred by users**
  - **Users may not always be able to fly preferred trajectories**
- **Solution:**
  - **Air: Cockpit Display of Traffic Information (CDTI)-equipped aircraft maneuver freely for separation assurance**
  - **Ground: Controller monitors separation (with complementary ground-based tools) and provides separation assurance for non-equipped aircraft**

En Route Free Flight

CE-5: Crew creates path and executes it.

- **Pilots are responsible for separation.**
- **High altitude controllers monitor traffic for safety and flow.**
- **Arriving aircraft are on Free Flight routes to the BAMBE meter fix.**
- **Pilots monitor their traffic displays and use CDTI to free maneuver to avoid traffic.**
- **Any changes in trajectory are down-linked to ATC and broadcast to equipped aircraft.**
- **A "super-sector" high altitude controller uses CTAS tools to monitor aircraft in the free flight airspace.**
- **TMA generates a sequence and schedule for all arriving aircraft at the north-west corner post.**
- **RTA and cruise speed advisories are automatically uplinked to arriving aircraft.**
- **Aircraft transition to positive ATC control before leaving FL290.**

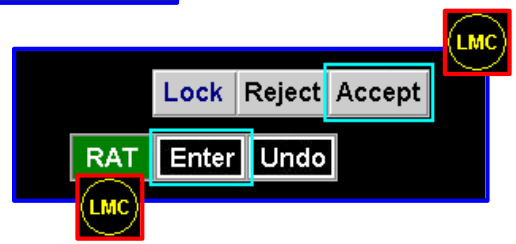
CDTI

Advanced – Route Assessment Tool (CE-5: Free Flight Airspace)

» Loss of Separation Alert [**LOS 10:45**]

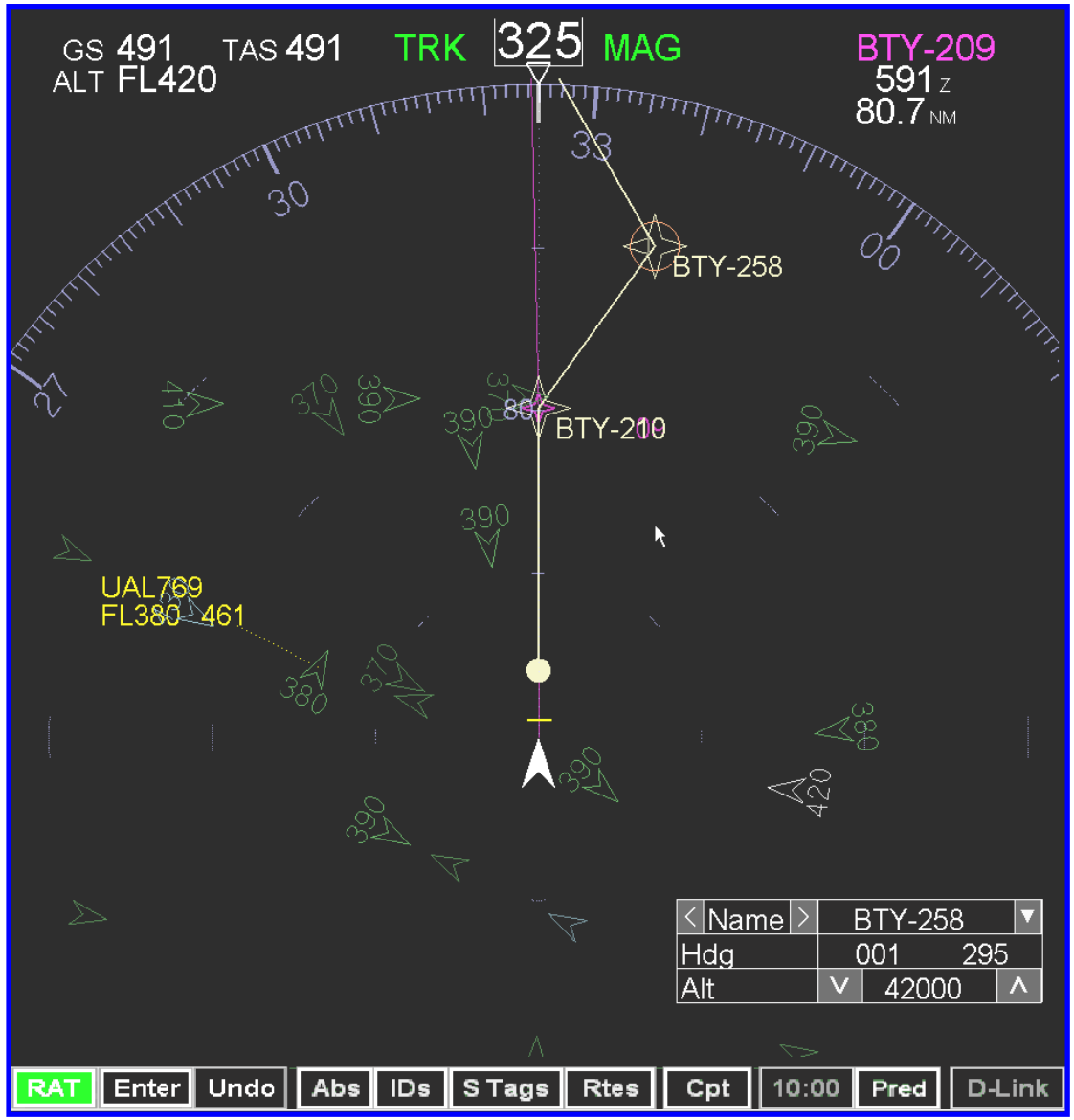
» Engage Route Assessment Tool - RAT 

» Modify ownship heading (speed, altitude) 

» Enter >> Accept, to execute new flight plan 

» Data link flight plan modification


GS 491 TAS 491
ALT FL420
TRK 325 MAG
BTY-209
662 Z
90.3 NM
ASA1286
FL390 448
BTY-209
UAL769
FL380 461
ALERT
LOS 15:11
LMC
RAT
Enter
Undo
Abs
IDs
S Tags
Rtes
Cpt
10:00
Pred
D-Link


GS 491
TAS 491
ALT FL420
TRK 325 MAG
BTY-209
591 Z
80.7 NM
BTY-258
BTY-209
UAL769
FL380 461
Name
BTY-258
Hdg
001 295
Alt
42000
RAT
Enter
Undo
Abs
IDs
S Tags
Rtes
Cpt
10:00
Pred
D-Link


GS 491
TAS 491
ALT FL420
TRK 325 MAG
BTY-210
540 Z
73.7 NM
BTY-258
BTY-210
Lock
Reject
Accept
LMC
RAT
Enter
Undo
LMC
Abs
IDs
S Tags
Rtes
Cpt
10:00
Pred
D-Link

CE 6:
Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance

- **Problem:**
  - **Potential traffic separation conflicts may cause controller-issued deviations that are conservative or not preferred by users**
  - **Users may not always be able to fly preferred trajectories**
- **Solution:**
  - **User and controller negotiate for efficient resolution of conflicts**
  - **User-controller data exchange (intent, winds) for improved trajectory prediction**
  - **Controller uses enhanced DSTs with conflict detection & resolution capabilities**
  - **ATC moves to a "trajectory-based" orientation**

En Route Phase – Free Flight With Approval

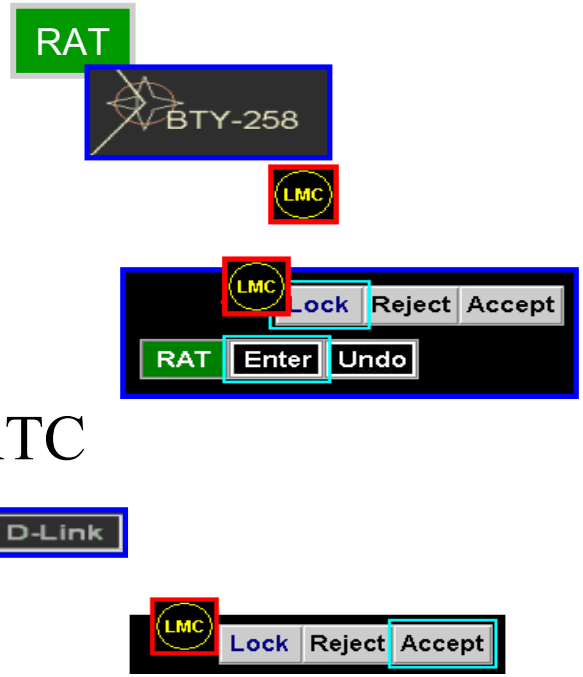
CE-6: Crew creates path, gets approval from ATC

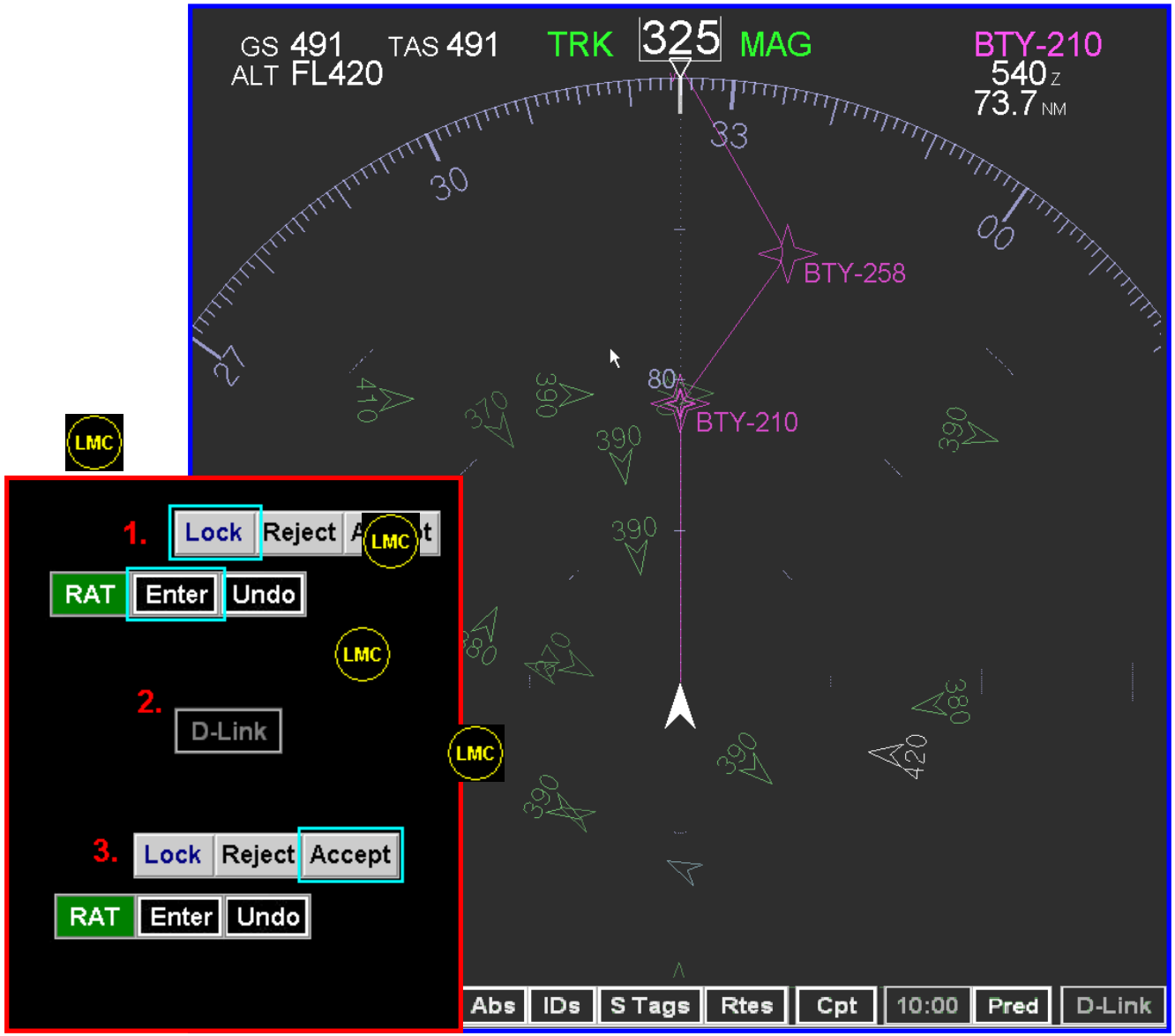
- **Controllers are responsible for separation.**
- **Aircraft are on FMS routes to the *BAMBE* meter fix.**
- **Pilots monitor their traffic display and can use CDTI to create paths to avoid traffic.**
- **Pilot requests for path changes are down-linked to ATC.**
- **A high altitude controller uses CTAS to check for conflicts on proposed path and approve changes.**
- **TMA generates a sequence and schedule for all arriving aircraft at the north-west corner post.**
- **RTA and cruise speed advisories are automatically uplinked to arriving aircraft.**

CDTI

Advanced – Route Assessment Tool (CE-6: Free Flight Airspace)

- Loss of Separation Alert [LOS 10:45]
- Engage Route Assessment Tool - RAT
- Modify ownship heading (speed, altitude)
- "Lock," and submit flight plan change to ATC
- Receive Data Link-ed ATC approval
- Click Accept, to execute new flight plan




GS 491 TAS 491
ALT FL420
TRK 325 MAG
BTY-210
540 Z
73.7 NM
BTY-258
BTY-210
LMC
1.
Lock
Reject
RAT
Enter
Undo
2.
D-Link
3.
Lock
Reject
Accept
RAT
Enter
Undo
Abs
IDs
S Tags
Rtes
Cpt
10:00
Pred
D-Link

CE 11:
Self-Spacing for Merging and In-trail Separation

- **Problem:**
  - **Conservative spacing buffers on final approach reduce arrival throughput and airport capacity**
- **Solution:**
  - **CDTI-equipped aircraft are cleared to maintain separation relative to a leading aircraft:**
    - **Flight deck displays and guidance for:**
      - **Self-spacing and merging**
      - **Fine tuning of fixed-time spacing**
  - **Controller displays & procedures for shared separation responsibility**

CE-11 Roles and Responsibilities
TRACON Self-spacing clearance

- TRACON self-spacing - ATC responsible for separation
  - Flight crew can be cleared to maintain in-trail spacing, +/- buffer
    - (for example … 70 sec +/- 10 sec)
  - Controller can cancel clearance at any time (redundant)

DAG Scenario Events - TRACON airspace

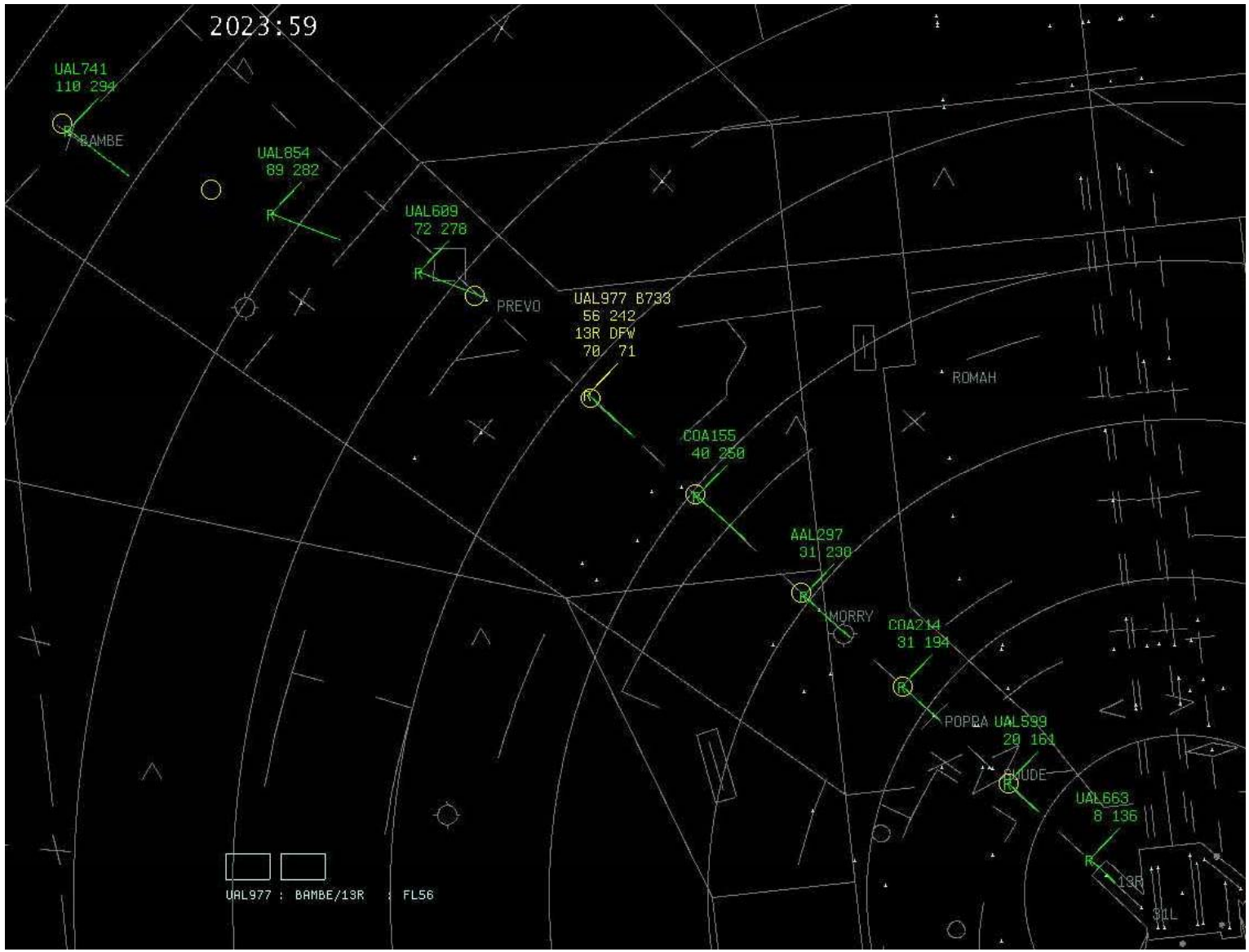
FMS approaches to runway 13R on the PREVO FMS Transition

- En route controllers deliver aircraft to the BAMBE meter fix on the TRACON boundary - (expected delivery accuracy is within 15 sec)
- TRACON controller clears aircraft to continue on the PREVO FMS Transition to RW13R.
- *"Descend via the PREVO FMS Transition, cleared ILS 13R approach."*
- TRACON controller gives speed clearance to fine tune in-trail spacing - (expected delivery accuracy at PREVO is within 15s)
- *"Slow to 240 knots."*
- If spacing is within tolerance, controller can clear by voice or datalink aircraft to self-space a specified number of seconds behind another aircraft.
- *"Follow AAL123, eighty seconds in-trail."*
- Pilot is responsible for maintaining separation behind lead aircraft - (expected delivery accuracy at FAF is within 5 sec)

Simulated traffic on the PREVO FMS transition to RW 13R

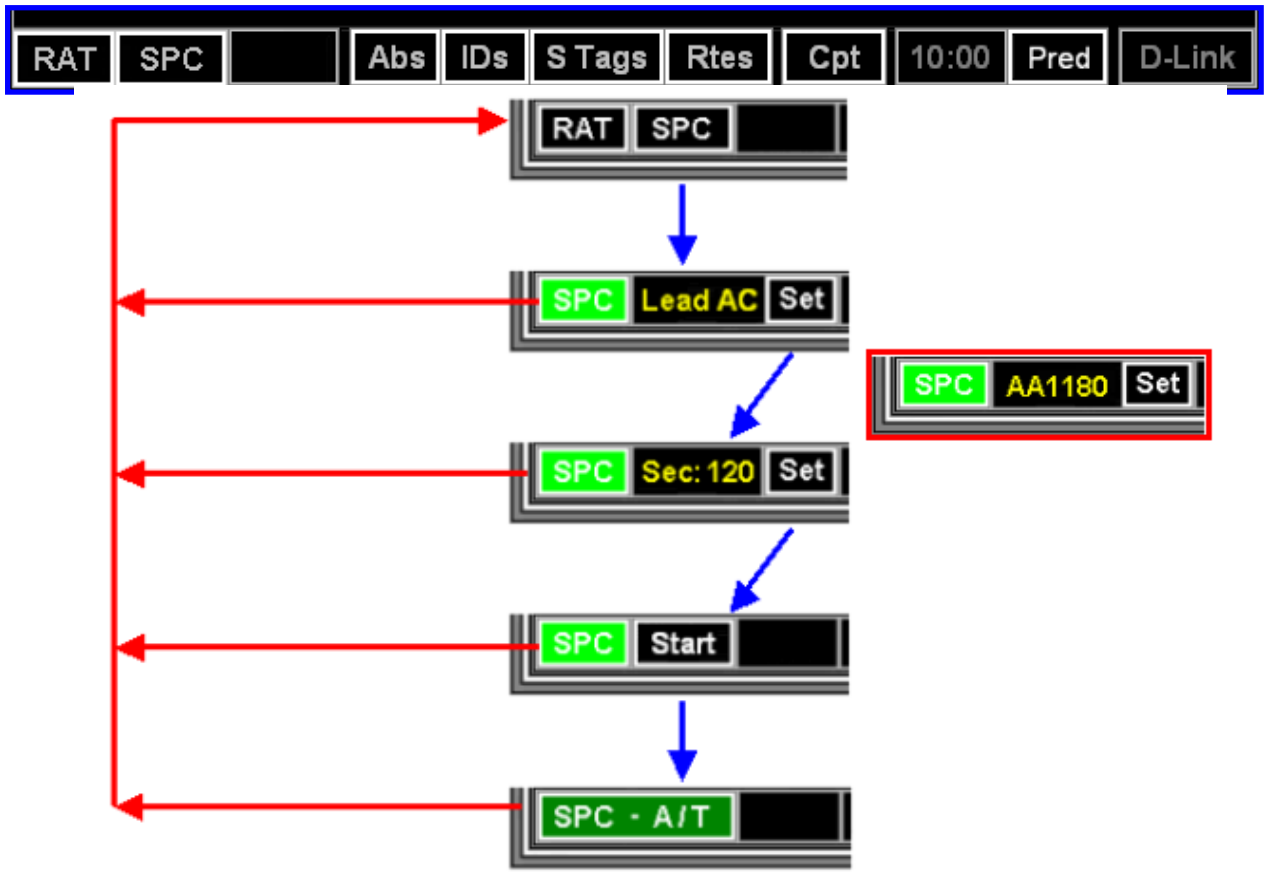
ADVANCED AIR TRANSPORTATION TECHNOLOGIES

DAG-TM Research | September 2001



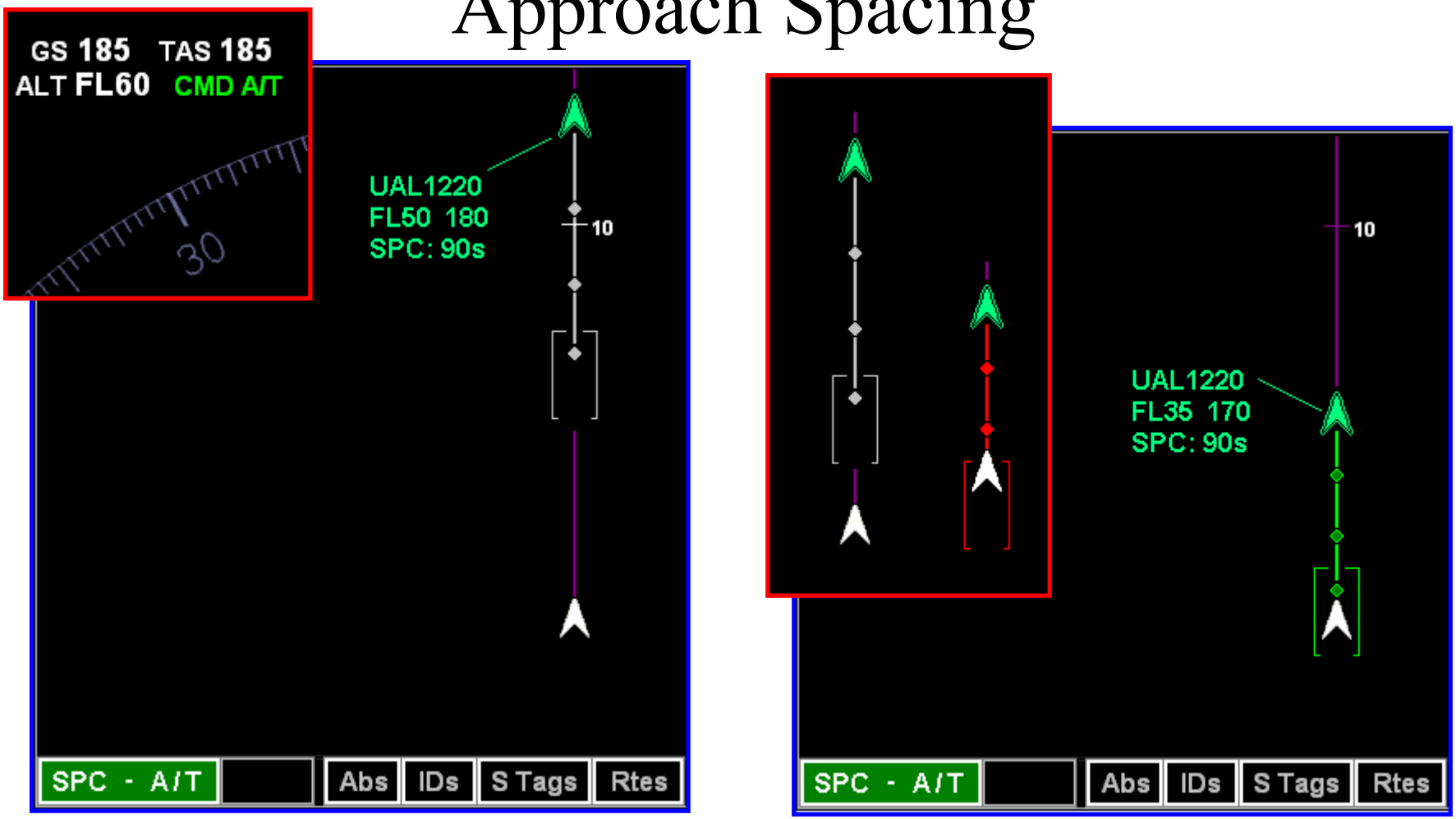
CDTI

Approach Spacing



CDTI

Approach Spacing



Research Plans

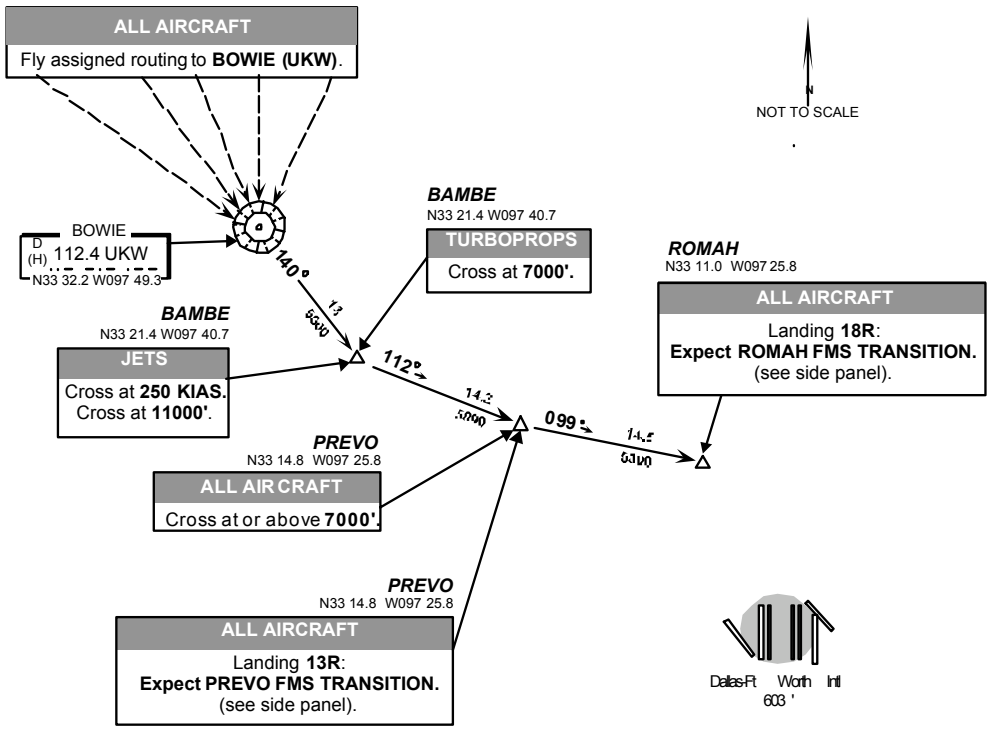
- Develop and test decision support tools
- Three years of DAG-TM research
  - Develop and clarify concepts
  - Involve users (pilots, controllers, and dispatchers)
  - Conduct laboratory demonstrations of concepts
- Goal is to evaluate feasibility and potential benefits
- Deliver information and prototypes to the FAA by 2004

BOWIE F2 ARRIVAL (UKWF2)
ROMAH (ROMAH) AND PREVO (PREVO) FMS TRANSITIONS TO ILS13R AND 1LS18R

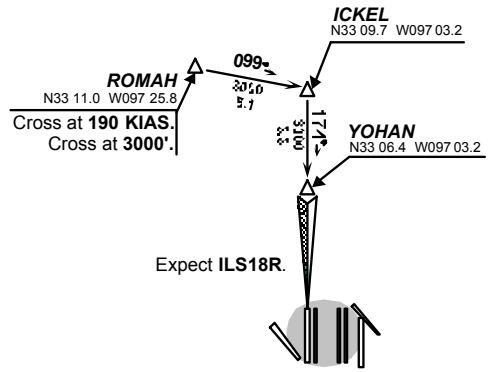
(/E or /F aircraft, RADAR required)

DALLAS-FT WORTH, TEXAS
DALLAS-FT WORTH INTL

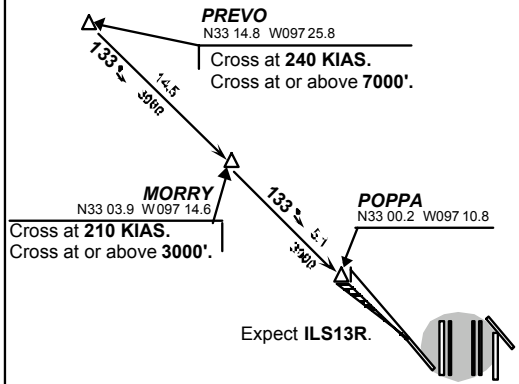
ATIS **123.77**
REGIONAL Approach **118.1 133.62**



ROMAH (ROMAH) FMS TRANSITION



PREVO (PREVO) FMS TRANSITION



Notes:

1. A self-spacing clearance overrides the charted speeds.
2. A speed clearance cancels the self - spacing clearance.

BOWIE F2 ARRIVAL NOTES:

1. *"Cleared to DFW via the BOWIE F2 Arrival."*
   - The BOWIE F2 Arrival includes the aircraft's assigned lateral route to **BOWIE.**
   - This is a clearance for the lateral routing only of the BOWIE F2 Arrival to **ROMAH.**

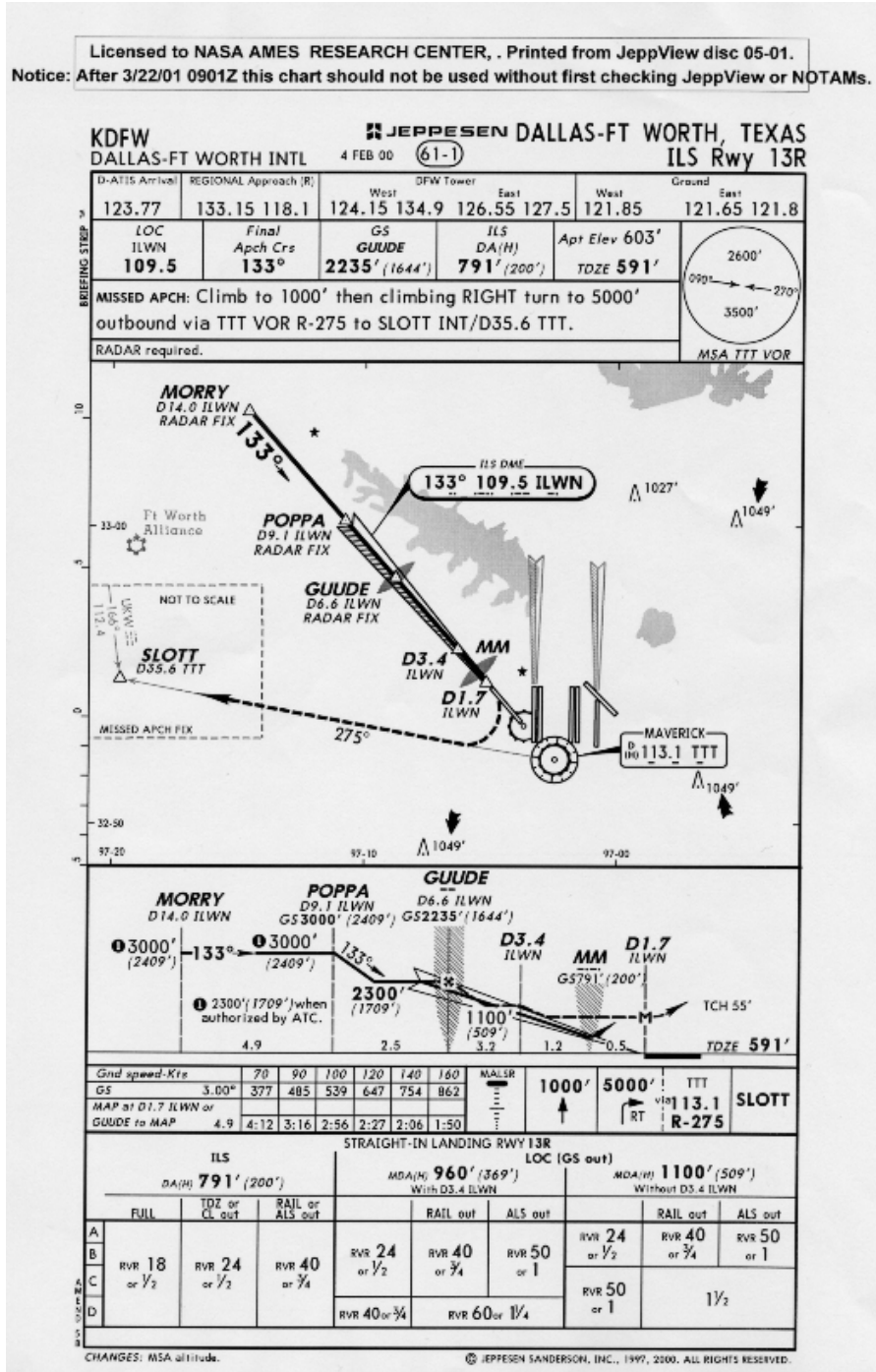
2. *"Descend via the BOWIE F2 Arrival, (descend at XXX IAS)."*
   - This is a clearance to descend at the VNAV Top-of-Descent to the published **BAMBE** altitude or other cleared altitude.
   - Vertical navigation is **not** at pilot's discretion.
   - Maintain current altitude until the VNAV Top-of-Descent.
   - Maintain cruise Mach in descent until reaching the cleared descent speed.
   - Report leaving altitude.
   - Comply with assigned speeds.

3. Advise Regional Approach on initial contact that you are on the BOWIE F2 Arrival.

ILS Rwy 13R Approach Chart

	distance	altitude	speed
BAMBE	41.8nm	11,000′	250
PREVO	27.5nm	7,000′	240
MORRY	13.0nm	3,000′	210
POPPA	7.9nm	3,000′	170
GUUDE	5.4nm	2,300′	150
13R	0.0nm	591′	135

The flying time from BAMBE to Rwy 13R is 600 seconds on the above speed profile.



END